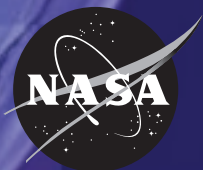
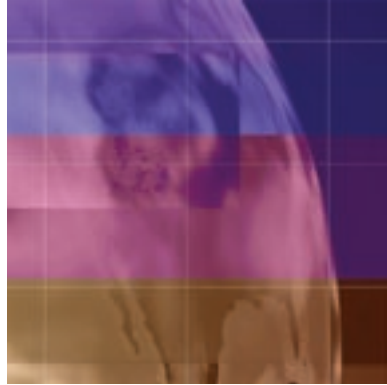


November 20, 2003
Volume 1, Revision 1.1

NASA's Implementation Plan for Space Shuttle Return to Flight and Beyond

*A periodically updated document
demonstrating our progress
toward safe return to flight
and implementation of the
Columbia Accident Investigation
Board recommendations*



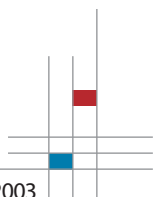


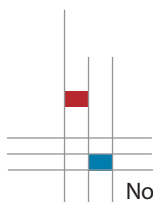
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An electronic version of this implementation plan is available at www.nasa.gov





November 20, 2003

NASA's Implementation Plan for Space Shuttle Return to Flight and Beyond

Revision 1.1 Summary

November 20, 2003



This revision to *NASA's Implementation Plan for Space Shuttle Return to Flight and Beyond* includes (1) our initial responses to additional data released by the *Columbia* Accident Investigation Board (CAIB), (2) preliminary cost estimates for return to flight activities, (3) a description of NASA's Space Shuttle return to flight suggestion process, and (4) updates to selected CAIB and Space Shuttle Program (SSP) actions. This revision does not change the entire document, but only selected pages which are listed below. These changed pages can be inserted into the existing document to reflect the Revision 1.1 update. A more detailed explanation of Revision 1.1 changes follows:

Initial Responses to Additional CAIB Data. In October 2003, the CAIB released additional data to supplement their August 2003, Volume I, CAIB Report. This Revision 1.1 provides NASA's initial responses to Volume II, Appendix D.a, also known as the "Deal Appendix." In this appendix, Brigadier General Duane Deal outlined concerns and made fourteen recommendations aimed at preventing another Shuttle accident. NASA's initial responses can be found in a new section 2.3 to this Implementation Plan.

Preliminary Cost Estimates for RTF. NASA's process for RTF includes developing cost estimates for RTF activities as they are defined. Since our RTF activities are at varying states of maturity, the cost estimates provided in this Revision 1.1 are not all-inclusive. The estimates represent those RTF activities that have been approved for implementation and funding by the Space Shuttle Program and verified by the RTF Planning Team. Estimates of total cost are presented, excluding reserves. This data can be found at the end of the Summary section.

NASA's Process for RTF Suggestions. As part of NASA's response to the CAIB recommendations, NASA put in place a means for NASA employees and the public to provide their ideas to help NASA safely return to flight. NASA created an electronic mailbox to receive RTF suggestions and a process for responding to each message individually, including information about where the message will be forwarded for further review and consideration. A description of the process and a table summarizing results to date are provided immediately following the Response Summaries.

Updates to Selected CAIB and SSP Actions. Status and schedule updates are provided to action SSP-1, Quality Planning and Requirements Document/Government Mandated Inspection points; CAIB Observation O10.4-3, KSC Quality Assurance Personnel Training Programs; and CAIB Observation O10.4-4, ISO 9000/9001, and Observation O10.5-3, NASA Oversight Process. These changes can be found in Part 2, Raising the Bar – Other Corrective Actions.

The following pages have been changes or added in this Revision 1.1:

Add Pages

i-a – i-b (Rev. 1.1 Summary)

xxxii-a – xxxii-d

xxxvi-a – xxxvi-b

2-75 – 2-90

Remove Pages

Title Page (Oct. 10, 2003)

ix (Oct. 15, 2003) – xii (Oct. 15, 2003)

2-1 (Oct. 15, 2003) – 2-2 (Sept. 8, 2003)

2-45 (Oct. 15, 2003) – 2-46 (Oct. 15, 2003)

2-47 (Oct. 15, 2003) – 2-48 (Oct. 15, 2003)

2-53 (Oct. 15, 2003) – 2-54 (Oct. 15, 2003)

A-3 (Oct. 15, 2003) – A-4 (Sept. 8, 2003)

Replace With Pages

Title Page (Nov. 20, 2003)

ix (Nov. 20, 2003) – xii (Nov. 20, 2003)

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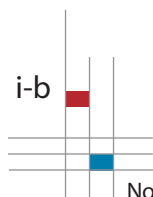
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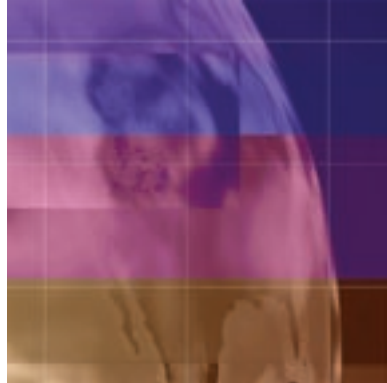
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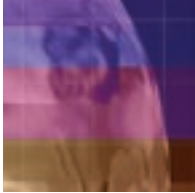
Changes made in Revision 1, issued October 15, 2003, are described in the following summary.





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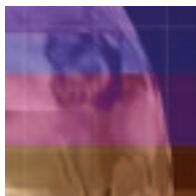
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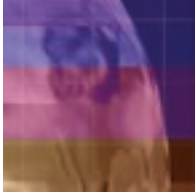
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Appendix A – NASA’s Return to Flight Process

Appendix B – Return to Flight Task Group

CAIB Supplemental Recommendations: Response to Volume II, Appendix D.a, Supplement to the Report

Volume II, Appendix D.a augments the CAIB Report recommendations. The Appendix outlines concerns raised by Brigadier General Duane Deal and others that, if addressed, might prevent a future accident. Some recommendations contained in the Appendix have already been addressed by this Plan and are referenced to the appropriate section. Although the recommendations are not numbered in Appendix D.a, we have assigned a number to the recommendations for tracking purposes.

Quality Assurance

D.a-1 Perform an independently led, bottom-up review of the Kennedy Space Center Quality Planning Requirements Document to address the entire quality assurance program and its administration. This review should include development of a responsive system to add or delete government mandatory inspections. Suggested Government Mandatory Inspection Point (GMIP) additions should be treated by higher review levels as justifying why they should not be added, versus making the lower levels justify why they should be added. Any GMIPs suggested for removal need concurrence of those in the chain of approval, including responsible engineers.

This recommendation is addressed in responses to SSP 1 and Observation 10.4-1 in sections 2.1 and 2.2. An independent assessment team, including representatives from NASA, industry, the Department of Defense, and the Federal Aviation Administration, has recently completed a bottoms-up review of the Quality Planning Requirements Document (QPRD) and activities associated with Government Mandatory Inspections (GMIPs) at the Kennedy Space Center and the Michoud Assembly Facility. Recommendations, findings, and observations from this assessment will be presented to the Space Shuttle Program in the near future.

D.a-2 Kennedy Space Center must develop and institutionalize a responsive bottom-up system to add to or subtract from Government Inspections in the future, starting with an annual Quality Planning Requirements Document review to ensure the program

reflects the evolving nature of the Shuttle system and mission flow changes. At a minimum, this process should document and consider equally inputs from engineering, technicians, inspectors, analysts, contractors, and Problem Reporting and Corrective Action to adapt the following year's program.

This recommendation is partially addressed in responses to SSP 1 and Observation 10.4-1 in sections 2.1 and 2.2. Shuttle Processing has assembled a team to address the QPRD change and a QPRD change process has been implemented. An initial survey of GMIPs has been accomplished and a temporary GMIP change process has been established. Status updates will be included in the next release of this Plan.

D.a-3 NASA Safety and Mission Assurance should establish a process inspection program to provide a valid evaluation of contractor daily operations, while in process, using statistically-driven sampling. Inspections should include all aspects of production, including training records, worker certification, etc., as well as Foreign Object Damage prevention. NASA should also add all process inspection findings to its tracking programs.

This recommendation is addressed in responses to Recommendation 4.2-5 and Observation 10.4-1. Status updates will be prepared as deemed necessary. NASA will implement a consistent definition of foreign object damage debris across all processing activities; current metrics will be improved; NASA will provide foreign object damage prevention surveillance throughout the entire processing timeline; and foreign object debris training will be updated and improved.

D.a-4 The Kennedy quality program must emphasize forecasting and filling personnel vacancies with qualified candidates to help reduce overtime and allow inspectors to accomplish their position description requirements (i.e., more than the inspectors performing government inspections only, to include expanding into completing surveillance inspections).

NASA uses two techniques for selecting and developing qualified Quality Assurance Specialists (QAS). Temporary and term employees can be hired to provide flexibility for short-term staffing issues. Permanent employee hires for QASs is preferred and in work. Formal training is required that includes classroom and on-the-job training.

D.a-5 Job qualifications for new quality program hires must spell out criteria for applicants, and must be closely screened to ensure the selected applicants have backgrounds that ensure that NASA can conduct the most professional and thorough inspections possible.

NASA has benchmarked the Department of Defense's and the Defense Contract Management Agency's training requirements to determine where we can directly use their training opportunities. A team of engineers and QASs from the Space Shuttle and International Space Station Programs has formed to develop and document a more robust training program.

D.a-6 Marshall Space Flight Center should perform an independently-led bottom-up review of the Michoud Quality Planning Requirements Document to address the quality program and its administration. This review should include development of a responsive system to add or delete government mandatory inspections. Suggested Government Mandatory Inspection Point (GMIP) additions should be treated by higher review levels as justifying why they should not be added, versus making the lower levels justify why they should be added. Any GMIPs suggested for removal should need concurrence of those in the chain of approval, including responsible engineers.

NASA commissioned an assessment team independent of the Space Shuttle Program to review the effectiveness of the mandatory inspection document employed at the Michoud Assembly Facility to define GMIPs. The assessment report is in final preparation and will be presented to the Space Shuttle Program for consideration in December 2003.

D.a-7 Michoud should develop and institutionalize a responsive bottom-up system to add to or subtract from Government Inspections in the future, starting with an annual Quality Planning Requirements Document review to ensure the program reflects the evolving nature of the Shuttle system and mission flow changes. Defense Contract Management Agency manpower at Michoud should be refined as an outcome of the QPRD review.

The Shuttle Propulsion Element located at the Marshall Space Flight Center is responsible for overseeing the Mandatory Inspection Document process and implementation of associated GMIPs for Michoud activities. This too was a focus of the independent assessment team activity.

Findings, observations, and recommendations will be forthcoming in the assessment report that will be delivered in December 2003.

D.a-8 Kennedy Space Center should examine which areas of ISO 9000/9001 truly apply to a 20-year-old research and development system like the Space Shuttle. Note: This item is currently Observation O10.4-4 in the Board report; however to avoid further diluting the quality program focus, it is urged this become a Recommendation.

In response to Observation 10.4-4, NASA commissioned an assessment team to review how ISO 9000/9001 is used. The team has established a review methodology and has partially completed the first step, determining the applicability of the ISO standard to United Space Alliance operations at KSC.

Orbiter Corrosion

D.a-9 Develop non-destructive evaluation inspections to detect and, as necessary, correct hidden corrosion.

The response to this recommendation will be included in our response to Observations 10.7-1, -2, -3, and -4 in section 2.2 of this Plan. Our response to date from the Vehicle Engineering Project is pending and has not been specified.

Hold-Down Post Cable Anomaly

D.a-10 NASA should evaluate a redesign of the Hold-Down Post Cable, such as adding a cross-strapping cable or utilizing a laser initiator, and consider advanced testing to prevent intermittent failure.

Shuttle Processing is reviewing the design of the hold-down post system and the anomaly that occurred during the STS-112 launch for potential improvements in system reliability. Many prelaunch process modifications have been identified for implementation, including installation of new cables and connectors and not allowing reuse, mandatory visual inspection using bore scopes for blind installations, and evaluation of a cross-strapped ordnance manifold at the hold-down post so that either a system A command or a system B command will cause an individual NASA Standard Initiator to fire. Other activities and enhancements are under evaluation.

Solid Rocket Booster Tank Attach Ring

D.a-11 NASA must reinstate a safety factor of 1.4 for the Attach Rings—which invalidates the use of ring serial numbers 15 and 16 in their present state—and replace all deficient material in the Attach Rings.

This recommendation is addressed in section 2.2, CAIB Observation 10.10-1 in the Implementation Plan. Solid Rocket Booster External Tank Attach Ring sets will be physically tested to verify compliance with the 1.4 factor of safety requirement before each flight until materials can be verified to be compliant.

Crew Survivability

D.a-12 To enhance the likelihood of crew survivability, NASA must evaluate the feasibility of improvements to protect the crew cabin of existing Orbiters.

NASA has a long-term, crew escape system evaluation effort that is included in the Service Life Extension Program portfolio. The Crew Survivability Working Group will consider options and make recommendations for protecting the crew cabin as it evaluates options to enhance crew survivability.

Reusable Solid Rocket Motor (RSRM) Segments Shipping Security

D.a-13 NASA and ATK Thiokol perform a thorough security assessment of the RSRM segment security, from manufacturing to delivery to Kennedy Space Center, identifying vulnerabilities and identifying remedies for such vulnerabilities.

NASA, in conjunction with the ATK Thiokol security program officials, will conduct a full security program vulnerability assessment of the ATK Thiokol RSRM production facility with the goal of identifying and mitigating security vulnerabilities. This assessment will coincide with the next shipment of RSRM segments to KSC.

Michoud Assembly Facility (MAF) Security

D.a-14 NASA and Lockheed Martin complete an assessment of the Michoud Assembly Facility security, focusing on items to eliminate vulnerabilities in its current stance.

NASA, in coordination with the Lockheed-Martin MAF security officials, will conduct a full security program vulnerability assessment of the MAF and External Tank (ET) production activity and the delivery of ETs to KSC.

NASA Space Shuttle Return to Flight (RTF) Suggestions

As part of NASA's response to the CAIB recommendations, the Administrator asked that a process be put in place for NASA employees and the public to provide their ideas to help NASA safely return to flight. With the first public release of NASA's RTF Implementation Plan on September 8, 2003, NASA created an electronic mailbox to receive RTF suggestions. The e-mail address is "RTFsuggestions@nasa.gov." A link to the e-mail address for RTF suggestions was posted on the NASA Web page "www.nasa.gov," near the link to the RTF Implementation Plan and the CAIB Report.

The first e-mail suggestion was received on September 8, 2003. Since then, NASA has received an average of 47 messages per week. NASA responds to each message individually, including answering any questions contained in the suggestion, and providing information about where the message will be forwarded for further review and consideration.

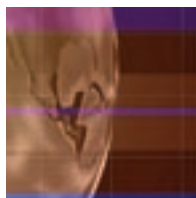
Many of the messages received are provided for review to a Project or Element Office within the Space Shuttle Program, the Safety and Mission Assurance organization, the Training and Leadership Development organization, the newly established NASA Engineering and Safety Center, or to the NASA Team formed to address Agencywide implications for organization and culture.

NASA organizations receiving suggestions are asked to review the message and use the suggestion as appropriate in their RTF activities. When a suggestion is forwarded, the recipient is encouraged to contact the individual who submitted the suggestion for additional information to assure that the suggestion's intent is clearly understood.

Table 1 provides a summary of our results to date and includes (1) the categories of suggestions; (2) the number of suggestions received per category; (3) examples of RTF suggestion content from each category; (4) "Action Pending" those suggestions that warranted further review by a project, program, or senior NASA manager(s); (5) "Closed" for those suggestions that required no further review once a reply was sent to the initiator; and (6) "Unprocessed" for suggestions that still require an initial review and reply.

Synopsis of Return to Flight Suggestions

| Category | No. of Suggestions | Example Suggestion Content |
|-------------------------------------|--------------------|---|
| Action Pending | | |
| Aerospace Technology | 2 | To quickly develop a short term alternative to the Space Shuttle based on existing technology and past Apollo-type capsule designs |
| SSP (General) | 18 | (1) Simulate Return to Launch Site scenarios. (2) Orbit a fuel tank to allow the Orbiter to refuel before entry and perform a slower entry. (3) Establish the ability to return the Shuttle without a crew onboard. |
| External Tank | 33 | (1) Insulate the inside of the ET to eliminate the possibility of foam debris hitting the Orbiter. (2) Shrink wrap the ET to prevent foam from breaking loose. |
| Solid Rocket Boosters | 1 | Please ensure that the SRB hold-down bolts are properly re-evaluated |
| Orbiter | 54 | (1) Develop a redundant layer of RCC panels on the Orbiter Wing Leading edge. (2) Cover the Wing Leading Edge with a titanium skin to protect it from debris during ascent |
| SSP Systems Integration | 5 | Try to use the same infrared imagery technology as the US military to enable monitoring and tracking the Space Shuttle during night launches |
| SSP Safety | 5 | (1) Develop new SRB's that can be thrust-controlled to provide a safer, more controllable launch. (2) Use rewards and incentives to promote the benefits of reliability and demonstrate the costs of failure. |
| NASA Safety and Mission Assurance | 8 | (1) Learn from the Naval Nuclear Reactors Program. (2) The Mandatory Inspection Point review should not be limited to just the MAF and KSC elements of the program. |
| NASA Engineering and Safety Center | 1 | (1) Use a group brainstorming approach to aid in identifying how systems might fail. (2) NESC needs to get involved during a project's start as well as during its mission operations. |
| NASA Culture | 23 | (1) Host a monthly employee forum for discussing ideas and concerns that would otherwise not be heard. (2) Senior leaders need to spend more time in the field to keep up with what is actually going on. |
| NASA Leadership/Management Training | 3 | Employees need to be trained while still in their current job to prepare them for increasing positions of responsibility. |
| NASA Public Affairs | 8 | NASA needs to dramatically increase media coverage to excite the public once again, to better convey the goals and challenges of human space flight, and to create more enthusiasm for a given mission. |
| Closed | 54 | (1) Use a current version of the Shuttle robotic arm to develop the extension boom for on-orbit inspection. (2) If Atlantis is not ready to fly, try using another Orbiter first. |
| Unprocessed | 71 | |
| Total (As of November 12, 2003) | 286 | |



Return to Flight Cost Summary

NASA's process for return to flight (RTF) includes developing cost estimates for activities in the implementation plans as they are refined. Our activities are in varying states of maturity. The figure that follows identifies those activities for RTF that have reached a level of maturity allowing reasonable cost estimates, and have been approved for funding by the Space Shuttle Program Requirements Control Board (PRCB) and verified by the RTF Planning Team (RTFPT). Included are their estimated total cost through run-out, which does not include any reserves. It includes only those items that have been approved for implementation. We will continue to provide updates as items mature.

Not included in cost estimates provided are additional RTF elements being evaluated for a start in FY 2004 and other RTF funding requirements resulting from a complete evaluation of the CAIB report, such as replacement of hardware (e.g., cargo integration, Orbiter pressure tanks); ground operations workforce flexibility; other agencies' on-orbit assessment; and program reserves. Several solutions to improve NASA's culture and some of the Space Shuttle Program's (SSP) actions detailed in "Raising the Bar – Other Corrective Actions" (referred to as SSP corrective actions for the remainder of this summary) will be integrated into existing processes and may not always require additional funding.

The proposed SSP solutions for all RTF actions will be reviewed before receiving final NASA implementation approval and included in future updates. This process applies to solutions to the CAIB recommendations as well as to the SSP corrective actions.

The PRCB has responsibility to direct studies of identified problems, formulate alternative solutions, select the best solution, and develop overall cost estimates. The membership of the PRCB includes the SSP Manager, Deputy Manager, all Project and Element Managers, Safety and Mission Assurance personnel, and the Team Leader of the RTFPT.

PRCB deliberations are further evaluated by the RTFPT to ensure that comprehensive, integrated, and cohesive approaches are selected to address the recommendations and solutions as outlined in this plan. The membership of the RTFPT group includes approximately 30 experienced senior personnel from the Office of Space Flight and its field centers (at JSC, KSC, MSFC, and SSC).

In the process of down-selecting to two or three "best options," the projects and elements approve funding to conduct tests, perform analysis, develop prototype hardware and flight techniques, and/or obtain contractor technical expertise that is outside the scope of existing contracts.

The Space Flight Leadership Council (SFLC) is regularly briefed on the overall activities and progress associated with RTF and becomes directly involved when the SSP and RTFPT are ready to recommend a comprehensive solution to a CAIB recommendation or SSP corrective action. The SFLC receives a technical discussion of the solution as well as an assessment of cost and schedule. With the concurrence of the SFLC, the SSP then receives the authority to proceed. The membership of the SFLC includes the Associate Administrator for the Office of Space Flight, Associate Deputy Administrator for Technical Programs, Deputy Associate Administrator for ISS and SSP, Associate Administrator for Safety and Mission Assurance, RTFPT Team Lead, Space Shuttle Program Manager, and the Office of Space Flight Center Directors (at JSC, KSC, MSFC, and SSC).

All recommended solutions are further reviewed, for both technical merit and to determine if the solution responds to the action, by the Return to Flight Task Group (also known as the Stafford-Covey Task Group).

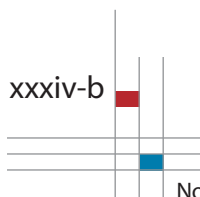
As decisions are made through the process described above, NASA will provide updated cost estimates in subsequent revisions of NASA's Implementation Plan for Space Shuttle Return to Flight and Beyond. Current estimates for NASA's initial RTF requirements are based on

cost estimating relationships derived from previous cost history, and typically include costs such as studies, engineering, development, integration, certification, verification, implementation, and retrofit, if appropriate. Again, these estimates do not currently include reserves,

they do not address the full spectrum of RTF activities still being assessed, and they have not yet been validated by detailed contractor bottoms-up reviews or independent analysis.

Return to Flight Budget Estimates/Implementation Plan Map for Initiated Items

| | (\$ Millions) | | Recommendation Numbers Map to Implementation Plan | | | | | | | | | | | | | | |
|--|---------------|-------|--|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|--------------------|
| | FY 03 | FY 04 | CAIB #3.2-1 | CAIB #3.3-1 | CAIB #3.3-2 | CAIB #3.3-3 | CAIB #3.3-4 | CAIB #3.4-1 | CAIB #3.4-2 | CAIB #3.4-3 | CAIB #4.2-1 | CAIB #4.2-3 | CAIB #6.4-1 | CAIB #7.5-1 | CAIB #7.5-2 | CAIB #9.1-1 | SSP Recommendation |
| Initiated RTF Activities | 59 | 174 | | | | | | | | | | | | | | | |
| Orbiter RCC Inspections | 1 | 21 | X | | | | | | | | | | X | | | | |
| On-orbit TPS Inspection & EVA Tile Repair | 19 | 38 | | | | | | | | | | | X | | | | |
| Orbiter TPS Hardening | 4 | 17 | | X | | | | | | | | | | | | | |
| Orbiter Certification / Verification | 2 | 3 | X | | X | X | | | | | | | | | | | |
| External Tank Items (Camera, Bipod Ramp, etc.) | 17 | 48 | X | | | | | X | X | X | | X | | | | | |
| SRB Items (Bolt Catcher, ETA Ring Invest., Camera) | 6 | 8 | | | | | | | X | X | X | | | | | | |
| Ground Camera Ascent Imagery Upgrade | 6 | 38 | | | | | | X | X | X | | | | | | | |
| Other (System Intgr. JBOSC Sys, SSME Tech Assess) | 4 | 1 | X | | X | X | | | | | | | | | | | |
| Stafford - Covey Team | 1 | 1 | | | | | | | | | | | | | | | X |
| Total SSP RTF Related | 60 | 175 | | | | | | | | | | | | | | | |
| Other RTF Related | | | | | | | | | | | | | | | | | |
| NASA Engineering and Safety Center (NESC) | | 45 | | | | | | | | | | | | X | X | X | |



xxxiv-b



Space Shuttle Program Return to Flight Actions

Space Shuttle Program Action 1

NASA will commission an assessment, independent of the Space Shuttle Program (SSP), of the Quality Planning and Requirements Document (QPRD) to determine the effectiveness of government mandatory inspection point (GMIP) criteria in assuring verification of critical functions before each Shuttle mission. The assessment will determine the adequacy of existing GMIPs to meet the QPRD criteria. Over the long term, NASA will periodically review the effectiveness of the QPRD inspection criteria against ground processing and flight experience to verify that GMIPs are effectively assuring safe flight operations.

BACKGROUND

The *Columbia* Accident Investigation Board report highlighted the Kennedy Space Center (KSC) and Michoud Assembly Facility (MAF) government mandatory inspection point (GMIP) processes as an area of concern. GMIP inspection and verification requirements are driven by the KSC Ground Operations Quality Planning and Requirements Document and the Marshall Space Flight Center Mandatory Inspection Documents.

NASA IMPLEMENTATION

NASA has chartered an Independent Assessment Team made up of experts from NASA, the Department of Defense, the aerospace industry, and the Federal Aviation Administration to evaluate the effectiveness of GMIP verification for the Shuttle Processing Directorate at KSC and the External Tank Project at MAF. The team will emphasize the review of policy and the evaluation of hardware processes associated with selected existing GMIPs. After the assessment is complete, its results, along with their potential effect on return to flight, will be provided to the NASA Offices of Space Flight (OSF) and Safety and Mission Assurance (OSMA), and to the Space Shuttle Program (SSP) for disposition.

To ensure the continued validity of the GMIP process, NASA will systematically audit the inspection criteria.

STATUS

In July 2003, OSF reviewed and approved a draft terms of the reference (TOR) document and the proposed membership for the GMIP's Independent Assessment Team. The Assessment Team was formally selected and chartered through a final TOR, signed by the Co-Chairs of the Space Flight Leadership Council and the Associate Administrator for OSMA. The team was briefed by, and held discussions with, all levels of management and the safety and mission assurance workforce at KSC and MAF. The team also performed walkdowns and gathered data at both locations.

The results of the Independent Assessment Team's work is consolidated in a report with findings, recommendations, and observations related to GMIP policy, processes, and workforce. The report links recommendations to specific facts and observations made by the team. Preliminary findings, recommendations, and observations have been briefed to OSMA and OSF. The initial report is currently under review and will be presented to Space Shuttle Program (SSP) management. Report completion is now targeted for the end of November 2003, with out-briefs at MAF and KSC in early December 2003. When the team report is formally released, the SSP intends to evaluate other SSP facilities and quality processes. Where similar findings/observations are found, the necessary changes will be implemented.

FORWARD WORK

The final report consisting of observations, findings, and recommendations will be provided to OSF and OSMA for disposition.

SCHEDULE

| Responsibility | Due Date | Activity/Deliverable |
|----------------|-----------------------|---|
| Headquarters | Jul 03 (Completed) | Assessment begun |
| Headquarters | Oct 03 (Completed) | Presentation to OSF and OSMA |
| Headquarters | Nov 03 | Final report issued |
| SSP | TBD | Implement changes to the Quality Process identified in the Final Report |





Columbia Accident Investigation Board

Observation 10.4-3

KSC quality assurance management must work with NASA and perhaps the Department of Defense to develop training programs for its personnel.

BACKGROUND

The *Columbia* Accident Investigation Board reported most of the training for quality engineers, process analysts, and quality assurance specialists was on-the-job training rather than formal training. In general, Kennedy Space Center (KSC) training is extensive for the specific hardware tasks (e.g., crimping, wire bonding, etc.), but includes approximately 160 hours of formal, on-the-job, and safety/area access training for each quality assurance specialist. However, there are deficiencies in basic quality assurance philosophy and skills.

NASA IMPLEMENTATION

NASA will benchmark quality assurance training programs as implemented by the Department of Defense (DoD) and Defense Contract Management Agency (DCMA). NASA's goal is to develop comparable training programs for the quality engineers, process analysts, and quality assurance specialists. The training requirements will be documented in our training records template.

STATUS

KSC has benchmarked with DoD and DCMA to understand their training requirements and to determine where we can directly use their training. A team consisting of engineers

and specialists from both the Shuttle and International Space Station Programs is meeting to develop and document a more robust training program.

FORWARD WORK

KSC will benchmark with DoD and the companies used to provide their quality assurance training. Later, KSC will document a comparable training program and update the training templates. Personnel will be given a reasonable timeframe in which to complete the training.

SCHEDULE

| Responsibility | Due Date | Activity/Deliverable |
|----------------|----------|---|
| KSC | Complete | Benchmark DoD and DCMA training programs |
| KSC | Mar 04 | Develop and document improved training requirements |
| KSC | Jun 04 | Complete personnel training |



Columbia Accident Investigation Board

Observation 10.4-4

Kennedy Space Center should examine which areas of International Organization for Standardization 9000/9001 truly apply to a 20-year-old research and development system like the Space Shuttle.

BACKGROUND

The *Columbia* Accident Investigation Board report highlighted Kennedy Space Center’s (KSC’s) reliance on the International Organization for Standardization (ISO) 9000/9001 certification. The report stated, “While ISO 9000/9001 expresses strong principles, they are more applicable to manufacturing and repetitive-procedure industries, such as running a major airline, than to a research-and-development, flight test environment like that of the Space Shuttle. Indeed, many perceive International Standardization as emphasizing process over product.” ISO 9000/9001 is also currently a contract requirement for United Space Alliance (USA).

NASA IMPLEMENTATION

NASA has assembled a team of Agency and industry experts to examine the ISO 9000/9001 standard and its applicability to the Space Shuttle Program. Specifically, this examination will address the following: 1) ISO 9000/9001 applicability to USA KSC operations; 2) how NASA should use USA’s ISO 9000/9001 applicable elements in evaluating USA performance; 3) how NASA currently uses USA’s ISO certification in evaluating its performance; and, 4) how NASA will use the ISO certification in the future.

STATUS

NASA has assembled the ISO 9000/9001 review team. The team has established a review methodology and has partially completed the first step, determining the applicability of the standard to USA KSC operations.

FORWARD WORK

The team is working to the schedule defined below which has changed since the last release of the Implementation Plan. After completion of all activities, the KSC surveillance plan will be updated to reflect the proper and implemented use of ISO 9000/9001 certification.

SCHEDULE

| Responsibility | Due Date | Activity/Deliverable |
|----------------|----------|--|
| KSC | Nov 03 | Identify applicability to USA KSC Operations |
| KSC | Jan 04 | Proper usage of standard in evaluating contractor performance |
| KSC | Jan 04 | Current usage of standard in evaluating contractor performance |
| KSC | Feb 04 | Future usage of standard and changes to surveillance or evaluation of contractor |
| KSC | Feb 04 | Presentation of Review |





Columbia Accident Investigation Board

Observation 10.5-3

NASA needs an oversight process to statistically sample the work performed and documented by Alliance technicians to ensure process control, compliance, and consistency.

BACKGROUND

The *Columbia* Accident Investigation Board noted the need for a statistically valid sampling program to evaluate contractor operations. Kennedy Space Center (KSC) currently samples contractor operations within the Space Shuttle Main Engine Processing Facility; however, the sample size is not statistically significant and does not represent all processing activities.

NASA IMPLEMENTATION

NASA will implement a sampling program and evaluate the resources required to collect sufficient samples to provide statistically significant data. The initial program will be very similar to the contractor-deployed program; however, NASA data will be maintained separately from the contractor data. NASA will develop and trend metrics to provide enhanced insight into contractor performance.

STATUS

KSC previously completed a pilot for a sampling program similar to that used by United Space Alliance. This sampling program has been implemented with two NASA process analysts.

FORWARD WORK

KSC will determine the resources required to provide a statistically significant sampling program. Metrics, including goals, will be developed and trended.

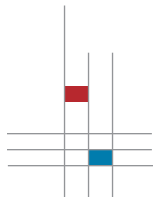
SCHEDULE

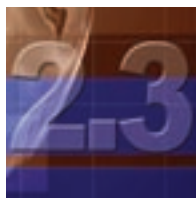
| Responsibility | Due Date | Activity/Deliverable |
|----------------|----------|--|
| KSC | Nov 03 | Provide resource estimate |
| KSC | Complete | Implement sampling program (not statistically valid until fully resourced) |
| KSC | Mar 04 | Develop metrics |



CAIB Report, Volume II, Appendix D.a, “Supplement to the Report”

Volume II, Appendix D.a, also known as the “Deal Appendix,” augments the CAIB Report and its condensed list of recommendations. The Appendix outlines concerns raised by Brigadier General Duane Deal and others that, if addressed, might prevent a future accident. The fourteen recommendations contained in this Appendix expand and emphasize CAIB report discussions of Quality Assurance processes, Orbiter corrosion detection methods, Solid Rocket Booster External Tank Attach Ring factor-of-safety concerns, crew survivability, security concerns relating to Michoud Assembly Facility, and shipment of Reusable Solid Rocket Motor segments. NASA is addressing each of the recommendations offered in Appendix D.a. Many of the recommendations have been addressed in previous versions of the Space Shuttle RTF Implementation Plan and, therefore, our response to those recommendations refers to the location in the Plan where our previously provided response is found. Although the recommendations are not numbered in Appendix D.a, we have assigned a number to each of the fourteen recommendations for tracking purposes.





Columbia Accident Investigation Board

Volume II, Appendix D.a, Quality Assurance Section,

Recommendation D.a-1 Review Quality Planning Requirements

Document Process

Perform an independently led, bottom-up review of the Kennedy Space Center Quality Planning Requirements Document to address the entire quality assurance program and its administration. This review should include development of a responsive system to add or delete government mandatory inspections. Suggested Government Mandatory Inspection Point (GMIP) additions should be treated by higher review levels as justifying why they should not be added, versus making the lower levels justify why they should be added. Any GMIPs suggested for removal need concurrence of those in the chain of approval, including responsible engineers.

BACKGROUND

The *Columbia* Accident Investigation Board noted the need for a responsive system for adding or deleting Government Mandatory Inspection Points (GMIPs), also noted in part of Observation O10.4-1 in section 2.2 of this Plan, and the need for a periodic review of the Quality Planning Requirements Document (QPRD). The Space Shuttle Program, Shuttle Processing Element located at the Kennedy Space Center is responsible for overseeing the QPRD process and implementation of associated GMIPs.

NASA IMPLEMENTATION, STATUS, FORWARD WORK, AND SCHEDULE

This recommendation is addressed in Section 2.1, Space Shuttle Program Action 1, and Section 2.2, Observation

10.4-1 of this Implementation Plan. Implementation of this recommendation has been in work since the issuance of the *Columbia* Accident Investigation Board Report, Volume I. NASA commissioned an assessment team, independent of the Space Shuttle Program, to review the effectiveness of the QPRD, its companion document at the Michoud Assembly Facility, referred to as the Mandatory Inspection Document, and the associated GMIPs. NASA continues work to improve this process through our defined implementation plan and will demonstrate our progress with this and future updates of our Plan.



Columbia Accident Investigation Board

Volume II, Appendix D.a, Quality Assurance Section,

Recommendation D.a-2 Responsive System to Update Government Mandatory Inspection Points

Kennedy Space Center must develop and institutionalize a responsive bottom-up system to add to or subtract from Government Inspections in the future, starting with an annual Quality Planning Requirements Document review to ensure the program reflects the evolving nature of the Shuttle system and mission flow changes. At a minimum, this process should document and consider equally inputs from engineering, technicians, inspectors, analysts, contractors, and Problem Reporting and Corrective Action to adapt the following year's program.

BACKGROUND

The *Columbia* Accident Investigation Board noted the need for a responsive system for updating Government Mandatory Inspection Points (GMIPs), including the need for a periodic review of the Quality Planning Requirements Document (QPRD). This issue is also noted in part of Observation O10.4-1 in Section 2.2 of this Implementation Plan. The Space Shuttle Program's Shuttle Processing Element, located at the Kennedy Space Center (KSC), is responsible for overseeing the QPRD process and implementation of associated GMIPs.

NASA IMPLEMENTATION

Shuttle Processing has assembled a team of inspectors, engineers, and managers, both NASA and contractor, to address the following items. First, Shuttle Processing is improving the change process for the QPRD. The changes will ensure anyone who requests a change receives a decision and the associated rationale to provide a feedback loop to the requestor. Furthermore, the change requests, disposition, and rationale will be tracked and maintained on line. The team is also developing a formal temporary GMIP process to accommodate one-time or infrequent GMIPs in a timely manner, while waiting for all the relevant parties to determine if the GMIP should become permanent. Finally, the team is providing a plan for

periodic review of the QPRD. As a part of this review, the team will survey the quality assurance specialists and systems engineers to identify GMIPs to be added or removed. Each candidate GMIP will be dispositioned through the improved GMIP change process.

STATUS

The team is reviewing the QPRD, has developed the QPRD change process, and is working on the temporary GMIP process. An initial survey of GMIPs has been conducted and a more thorough survey will follow.

SCHEDULE

| Responsibility | Due Date | Activity/Deliverable |
|------------------------|----------|--|
| KSC Shuttle Processing | Complete | Develop and implement GMIP change process |
| KSC Shuttle Processing | Jan 03 | Develop and implement temporary GMIP process |
| KSC Shuttle Processing | Jun 04 | Develop process for and review of QPRD |



Columbia Accident Investigation Board

Volume II, Appendix D.a, Quality Assurance Section,

Recommendation D.a-3 Statistically Driven Sampling of Contractor Operations

NASA Safety and Mission Assurance should establish a process inspection program to provide a valid evaluation of contractor daily operations, while in process, using statistically-driven sampling. Inspections should include all aspects of production, including training records, worker certification, etc., as well as Foreign Object Damage prevention. NASA should also add all process inspection findings to its tracking programs.

BACKGROUND

The *Columbia* Accident Investigation Board noted the need for a statistically valid sampling program to evaluate contractor operations. Kennedy Space Center currently samples contractor operations within the Space Shuttle Main Engine Processing Facility; however, the sample size is not statistically significant and does not represent all processing activities.

NASA IMPLEMENTATION, STATUS, FORWARD WORK, AND SCHEDULE

This recommendation is addressed in Section 2.2, Observation 10.5-3 of this Implementation Plan. Implementation of this recommendation has been in work since the release of the *Columbia* Accident Investigation Board Report, Volume I. NASA continues to address this issue through our defined implementation plan and will demonstrate our progress in this and future updates of our Plan.



Columbia Accident Investigation Board

Volume II, Appendix D.a, Quality Assurance Section,

Recommendation D.a-4 Forecasting and Filling Personnel Vacancies

The KSC quality program must emphasize forecasting and filling personnel vacancies with qualified candidates to help reduce overtime and allow inspectors to accomplish their position description requirements (i.e., more than the inspectors performing government inspections only, to include expanding into completing surveillance inspections.)

BACKGROUND

The *Columbia* Accident Investigation Board expressed concern regarding staffing levels of Quality Assurance Specialists (QAS) at Kennedy Space Center (KSC) and Michoud Assembly Facility (MAF). Specifically, they stated that staffing processes must be sufficient to select qualified candidates in a timely manner. Previously, KSC hired three QAS through a step program, none of whom had previous experience in quality assurance. The step program was a human resources sponsored effort to provide training and mobility opportunities to administrative staff. Of the three, only one remains a QAS. In addition to hiring qualified candidates, staffing levels should be sufficient to ensure the QAS function involves more than just inspection. Additional functions performed should include hardware surveillance, procedure evaluations, and assisting in audits.

NASA IMPLEMENTATION

NASA currently uses two techniques for selecting and developing qualified QAS. First, NASA can hire a QAS at the GS-7, GS-9, or GS-11 level if the candidate meets a predetermined list of requirements and experience. QAS candidates at all levels require additional training. Candidates selected at lower grades require additional classroom and on-the-job training before being certified as a QAS. NASA also uses a cooperative education program that brings in college students as part of their education process. This program is designed to develop QAS or quality control technicians for NASA and the contractor. The program is an extensive two-year

program, including classroom and on-the-job training. At the end of the cooperative education program, if the student does not demonstrate the required proficiency, NASA will not hire her or him.

Hiring practices have also improved. NASA can hire temporary or term employees. Although permanent hiring is preferred, this practice provides flexibility for short-term staffing issues. Examples include replacements for QAS military reservists who deploy to active duty and instances when permanent hiring authority is not immediately available.

Several QAS are deploying a hardware surveillance program. This program will define the areas in which hardware surveillance will be performed, the checklist of items to be assessed, the number of hardware inspections required, and the data to be collected.

STATUS

KSC has addressed the hiring issue. Training issues identified are addressed in Section 2.2, Observation O10.4-3. A team has been formed to develop, pilot, and deploy a hardware surveillance program.

FORWARD WORK

KSC will run a pilot hardware surveillance program, deploy it in the Orbiter Processing Facility (OPF), and then migrate it to the remaining facilities.

SCHEDULE

| Responsibility | Due Date | Activity/Deliverable |
|----------------|----------|---|
| KSC | Complete | Develop and implement processes for timely hiring of qualified candidates |
| KSC | Dec 03 | Develop and implement hardware surveillance program in the OPFs |
| KSC | Mar 04 | Deploy hardware surveillance program to all QAS facilities |
| KSC | Mar 04 | Develop reporting metric |
| KSC | Apr 04 | Develop and implement procedure evaluation |



Columbia Accident Investigation Board

Volume II, Appendix D.a, Quality Assurance Section,

Recommendation D.a-5 Quality Assurance Specialist Job Qualifications

Job qualifications for new quality program hires must spell out criteria for applicants, and must be closely screened to ensure the selected applicants have backgrounds that ensure that NASA can conduct the most professional and thorough inspections possible.

BACKGROUND

The *Columbia* Accident Investigation Board expressed concern regarding staffing qualifications of Quality Assurance Specialists (QAS) at Kennedy Space Center (KSC). Previously, KSC hired three QAS through a step program, none of whom had previous experience in quality assurance. Of the three, only one remains as a QAS.

NASA IMPLEMENTATION

NASA currently uses two techniques for selecting and developing qualified QAS. First, NASA can hire a QAS at the GS-7, GS-9, or GS-11 level if the candidate meets a predetermined list of requirements and experience. QAS candidates at all levels require additional training. Candidates selected at lower grades require additional classroom and on-the-job training before being certified as a QAS. NASA also uses a cooperative education program that brings in college students as part of their education process. This program is designed to develop QAS or quality control technicians for NASA and the contractor. The program is an extensive two-year program, including classroom and on-the-job training. At the end of the cooperative education program, if the student does not demonstrate the required proficiency, NASA will not hire the individual.

NASA will benchmark assurance training programs that are implemented by the Department of Defense (DoD) and Defense Contract Management Agency (DCMA). NASA's present goal is to develop a comparable training program for the quality engineers, process analysts, and QAS. The training requirements will be documented in our formal training records template. Additional information on our training plan is found in Section 2.2, Observation O10.4-3.

STATUS

NASA has benchmarked with DoD and DCMA to understand their training requirements and to determine where we can directly use their training. A team consisting of engineers and QAS in both the Shuttle and International Space Station Programs has been formed to develop and document a more robust training program.

FORWARD WORK

KSC will document a comparable training program and update the training templates. Personnel not meeting the new training requirements will be given a reasonable timeframe to complete the training.

SCHEDULE

| Responsibility | Due Date | Activity/Deliverable |
|----------------|----------|---|
| KSC | Complete | Develop and implement processes for hiring and developing qualified QAS |
| KSC | Nov 03 | Benchmark DoD and DCMA training programs (from O10.4-3) |
| KSC | Jan 04 | Develop and document improved training requirements (from O10.4-3) |
| KSC | Jun 04 | Complete personnel training (from O10.4-3) |



Columbia Accident Investigation Board

Volume II, Appendix D.a, Quality Assurance Section,

Recommendation D.a-6 Review Mandatory Inspection Document Process

Marshall Space Flight Center should perform an independently-led bottom-up review of the Michoud Quality Planning Requirements Document to address the quality program and its administration. This review should include development of a responsive system to add or delete government mandatory inspections. Suggested Government Mandatory Inspection Point (GMIP) additions should be treated by higher review levels as justifying why they should not be added, versus making the lower levels justify why they should be added. Any GMIPs suggested for removal should need concurrence of those in the chain of approval, including responsible engineers.

BACKGROUND

The *Columbia* Accident Investigation Board noted the need for a responsive system for adding or deleting Government Mandatory Inspection Points (GMIPs), including those at the Michoud Assembly Facility (MAF), also noted in part of Observation O10.4-1 in Section 2.2 of this Plan, and the need for a periodic review of the Quality Planning Requirements Document (QPRD). The Shuttle Propulsion Element at the Marshall Space Flight Center is responsible for overseeing the Mandatory Inspection Document process and implementation of associated GMIPs.

NASA IMPLEMENTATION, STATUS, FORWARD WORK, AND SCHEDULE

This recommendation is addressed in Section 2.1, Space Shuttle Program Action 1 and Section 2.2, Observation 10.4-1 of this Implementation Plan. Implementation of this recommendation has been in work since the issuance of the Columbia Accident Investigation Board Report, Volume I. NASA commissioned an assessment team, independent of the Space Shuttle Program to review the effectiveness of the QPRD and its companion document at the MAF, referred to as the Mandatory Inspection Document, and the associated GMIPs. NASA continues efforts to improve this process through our defined implementation plan and will demonstrate our progress with this and future updates of our Plan.



Columbia Accident Investigation Board

Volume II, Appendix D.a, Quality Assurance Section,

Recommendation D.a-7 Responsive System to Update Government

Mandatory Inspection Points at the Michoud Assembly Facility

Michoud should develop and institutionalize a responsive bottom-up system to add to or subtract from Government Inspections in the future, starting with an annual Quality Planning Requirements Document review to ensure the program reflects the evolving nature of the Shuttle system and mission flow changes. Defense Contract Management Agency manpower at Michoud should be refined as an outcome of the QPRD review.

BACKGROUND

The *Columbia* Accident Investigation Board noted the need for a responsive system for updating Government Mandatory Inspection Points (GMIPs), including the need for a periodic review of the Quality Planning Requirements Document (QPRD). This issue is also noted in part of Observation O10.4-1 in Section 2.2 of this Implementation Plan. The Space Shuttle Program Shuttle Processing Element located at the Kennedy Space Center is responsible for overseeing the QPRD process and implementation of associated GMIPs.

NASA IMPLEMENTATION, STATUS, FORWARD WORK, AND SCHEDULE

This recommendation is addressed in Section 2.1, Space Shuttle Program Action 1 and Section 2.2, Observation 10.4-1 of this Implementation Plan. Implementation of this recommendation has been in work since the issuance of the *Columbia* Accident Investigation Board Report, Volume I. NASA commissioned an assessment team, independent of the Space Shuttle Program, to review the effectiveness of the QPRD, its companion at the Michoud Assembly Facility, referred to as the Mandatory Inspection Document, and the associated GMIPs. NASA continues efforts to improve this process through our defined implementation plan and will demonstrate our progress with this and future updates of our Plan.



Columbia Accident Investigation Board

Volume II, Appendix D.a, Quality Assurance Section,

Recommendation D.a-8 Use of ISO 9000/9001

Kennedy Space Center should examine which areas of ISO 9000/9001 truly apply to a 20-year-old research and development system like the Space Shuttle.

BACKGROUND

The *Columbia* Accident Investigation Board report highlighted Kennedy Space Center's reliance on the International Organization for Standardization (ISO) 9000/9001 certification. The report stated, "While ISO 9000/9001 expresses strong principles, they are more applicable to manufacturing and repetitive-procedure industries, such as running a major airline, than to a research-and-development, flight test environment like that of the Space Shuttle. Indeed, many perceive International Standardization as emphasizing process over product." Currently, ISO 9000/9001 certification is a contract requirement for United Space Alliance.

NASA IMPLEMENTATION, STATUS, FORWARD WORK, AND SCHEDULE

This recommendation is addressed in Section 2.2, Observation 10.4-4, of this Implementation Plan. Implementation of this recommendation has been in work since the release of the *Columbia* Accident Investigation Board Report, Volume I. NASA continues efforts to improve this process through our defined implementation plan and will demonstrate our progress with this and future updates of our Plan.



Columbia Accident Investigation Board

Volume II, Appendix D.a, Quality Assurance Section,

Recommendation D.a-9 Orbiter Corrosion

Develop non-destructive evaluation inspections to detect and, as necessary, correct hidden corrosion.

BACKGROUND

The Space Shuttle Program has initiated an action to assess the *Columbia* Accident Investigation Board observations related to corrosion damage in the Orbiters. This action has been assigned to the Orbiter Project Office.

NASA IMPLEMENTATION, STATUS, FORWARD WORK, AND SCHEDULE

This recommendation is addressed in Section 2.2, Observation 10.7-1 through 10.7-4 of this Implementation Plan. Implementation of this recommendation has been in work since the release of the *Columbia* Accident Investigation Board Report, Volume I. NASA continues efforts to improve this process through our defined implementation plan and will demonstrate our progress with this and future updates of our plan.



Columbia Accident Investigation Board

Volume II, Appendix D.a, Quality Assurance Section,

Recommendation D.a-10 Hold-Down Post Cable Anomaly

NASA should evaluate a redesign of the Hold-Down Post Cable, such as adding a cross-strapping cable or utilizing a laser initiator, and consider advanced testing to prevent intermittent failure.

BACKGROUND

The Shuttle Hold-Down Post (HDP) pyrotechnic release system is designed to cleanly release the Space Shuttle Vehicle from the Mobile Launch Platform (MLP) HDPs after receiving a signal from the Orbiter General Purpose Computers and the Orbiter Master Event Controller at T-0. Release is normally accomplished by simultaneously firing two redundant pyrotechnic charges called NASA Standard Initiators (NSIs) on each of eight Solid Rocket Booster (SRB) HDP stud frangible nuts. Two independent ground-based Pyrotechnic Initiation Control (PIC) systems, A and B, are used to receive the command and to distribute the firing signals to each HDP. On STS-112, the system A Fire 1 command was not received by the ground-based PIC system; however, the redundant system B functioned properly and fired all system B NSIs, separated the frangible nuts, and enabled the release of the stud frangible nuts on all posts. As a result, the Shuttle safely separated from the MLP. NASA was unable to conclusively isolate the anomaly in any of the failed components. The most probable cause was determined to be an intermittent connection failure at the MLP-to-Orbiter interface at the Tail Service Mast (TSM) caused by the dynamic vibration environment after main engine start. Several contributing factors were identified, including ground-side connector corrosion at the TSM T-0 umbilical, weak connection spring force, potential non-locked Orbiter connector savers, lack of proper inspections, and a blind (nonvisually verified) mate between the ground cable and the Orbiter connector saver.

NASA IMPLEMENTATION

Since the NASA-initiated STS-112 investigation team concluded a TSM cable intermittent connection most likely caused the anomaly, Kennedy Space Center (KSC) has implemented a number of processing changes to greatly reduce the possibility of another intermittent condition at the TSM. The ground cables from the Orbiter interface to the TSM bulkhead plate are now replaced after each use; reuse after inspection was previously allowed. The ground connector springs that maintain the mating force against the Orbiter T-0 umbilical are all removed and tested to verify

the spring constants meet specification between each flight. Cables from the TSM bulkhead plate to PIC rack were previously inspected for damage, replaced as needed, and thoroughly tested. The Orbiter T-0 connector savers are inspected before each flight and are now secured with safety wire before the MLP cables are connected. New ground cables are thoroughly inspected before mate to the Orbiter. In addition, the connection process was enhanced to provide a bore scope optical verification of proper mate.

For STS-114 Return to Flight, the Space Shuttle Program is implementing several design changes and enhancements to further reduce the risk of a similar event. The Orbiter Project is adding redundant command paths for each HDP Arm, Fire 1, Fire 2, and return circuits from the Orbiter through separate connectors on the Orbiter/TSM umbilical. The Ground Support Equipment cables will be modified to extend the signals to the ground PIC rack solid-state switches. This modification adds copper path redundancy through the most dynamic and susceptible environment in the PIC system. Additionally, the KSC Shuttle Processing Project is redesigning and replacing all electrical cables from the Orbiter T-0 umbilical, through the TSMs, to their respective distribution points. The new cables will be factory constructed with a more robust insulation and be better suited for the environment in which they are used. This new cable design also eliminates the old style standard polyimide ("Kapton") wire insulation that can be damaged by handling and degrades with age.

Space Shuttle Program technical experts have investigated laser-initiated ordnance devices and have concluded that there would be no functional improvement in the ground PIC system operation. Although laser-initiated ordnance has positive capabilities, no conclusive benefit for use on the Space Shuttle systems has been confirmed. Additionally, use of laser-initiated ordnance would have only changed the firing command path from the ground PIC rack to each of the HDP ordnance devices. This would not change or have any impact on master command path failures experienced during the STS-112 launch, since they would still be electrical copper paths.

In a separate action, the Shuttle Processing team is investigating the addition of a cross-strapped ordnance manifold at the HDPs so that either a system A command or a system B command will cause both NSIs in any individual HDP to fire. This new manifold will eliminate the failure scenario of a single capacitor discharge from the ground PIC rack out to a HDP causing only one NSI detonation at that HDP. With the cross-strapping modification, either redundant capacitor discharge will detonate both booster cartridges on each nut simultaneously. The NSI bridgewire circuits are electrically tested several times during the launch count-down activities to verify that the copper paths through the NSIs are intact. As an added benefit, the cross-strapping of the NSIs will eliminate the nonsimultaneous firing (skew time) of the NSIs as a factor in “stud hang-up.”

NASA has been engaged for more than three years with the joint Department of Defense/NASA/Federal Aviation Agency/industry aging aircraft wiring community to develop, test, and implement fault-detection methods and equipment to find emerging wire anomalies and intermittent failures before they prevent electrical function. Several tools have been developed and tested for that purpose but no tool is available with a conclusive ability to guarantee total wire function, especially under dynamic conditions that cannot be tested in place just before use.

STATUS

Proposed hardware modifications and development activity status include:

1. The TSM cable preliminary redesign is completed and has been designated a “return to flight” mandatory modification by the Shuttle Processing Project.
2. The Orbiter Project is implementing the T-0 redundancy modification in the Orbiter cable system and T-0 connectors. KSC will modify ground-side circuits accordingly.
3. The Space Shuttle Program is not currently considering laser pyrotechnic firing for the Shuttle Program but may readdress the issue in the future as the technology matures and the flight vehicle is upgraded.
4. NASA is currently supporting two separate strategies to determine wiring integrity. In addition, NASA is engaged with the Department of Defense and the Federal Aviation Agency to encourage further studies and projects.

FORWARD WORK

1. The evaluation team for laser initiation of pyrotechnics will continue to monitor hardware development for application to Shuttle hardware.
2. The NASA team will continue to engage in development of emerging wire fault detection and fault location tools with the government/industry wiring community. NASA will advocate funding for tool development and implement all new effective methods.

SCHEDULE

| Responsibility | Due Date | Activity/Deliverable |
|-----------------------|----------|---|
| Space Shuttle Program | Dec 03 | Approve new Operational Maintenance Requirements and Specification Documents requirement for specific ground cable inspections as a condition for mating |
| Orbiter Project | Dec 03 | Provide redundant firing path in the Orbiter for HDP separation |
| Shuttle Integration | Feb 04 | Implement cross-strapping for simultaneous NSI detonation |
| Space Shuttle Program | May 04 | Report on new-technology wire fault-detection capability |
| Space Shuttle Program | May 04 | New laser-firing study task |
| KSC | RTF | Modify, install, and certify the ground cabling to protect against damage and degradation and to implement a redundant ground electrical path to match orbiter commands |



Columbia Accident Investigation Board

Volume II, Appendix D.a, Quality Assurance Section,

Recommendation D.a-11 Solid Rocket Booster External Tank Attach Ring

NASA must reinstate a safety factor of 1.4 for the Attach Rings—which invalidates the use of ring serial numbers 15 and 16 in their present state—and replace all deficient material in the Attach Rings.

BACKGROUND

The *Columbia* Accident Investigation Board found that NASA often used analysis when testing would have been more appropriate to determine material properties. NASA's use of analysis to determine the adequacy of the tensile strength of the Solid Rocket Booster (SRB) to External Tank (ET) attachment rings was given as an example of a case where subsequent testing determined the factor of safety to be below the requirement threshold of 1.4.

NASA IMPLEMENTATION, STATUS, FORWARD WORK, AND SCHEDULE

This recommendation is addressed in Section 2.2, Observation 10.10-1, of this Implementation Plan. Implementation of this recommendation has been in work since the release of the *Columbia* Accident Investigation Board Report, Volume I. NASA continues to address this issue and will demonstrate our progress in updates of our Implementation Plan. SRB ET Attach Rings sets will be physically tested to verify compliance with the 1.4 factor-of-safety requirement before each flight until materials can be verified as compliant.



Columbia Accident Investigation Board

Volume II, Appendix D.a, Quality Assurance Section,

Recommendation D.a-12 Crew Survivability

To enhance the likelihood of crew survivability, NASA must evaluate the feasibility of improvements to protect the crew cabin on existing Orbiters.

BACKGROUND

The *Columbia* Accident Investigation Board found that in both the *Challenger* and the *Columbia* accidents, the crew cabin initially survived the disintegration of the Orbiter intact. Evidence indicates that the *Challenger* crew cabin remained intact until it impacted the Atlantic Ocean and that the *Columbia* crew cabin maintained structural integrity until the entry heating environment began to disintegrate its aluminum skin, leading to its destruction.

NASA IMPLEMENTATION, STATUS, FORWARD WORK, AND SCHEDULE

This recommendation is addressed in Section 2.2, Observation 10.2-1, of this Implementation Plan. Implementation of this recommendation has been in work since the release of the *Columbia* Accident Investigation Board Report, Volume I. NASA continues efforts to improve this process through our defined implementation plan and will demonstrate our progress with this and future updates of our Plan. The Crew Survivability Working Group will consider options and make recommendations for protecting the crew cabin as it evaluates options to enhance crew survivability.



Columbia Accident Investigation Board

Volume II, Appendix D.a, Quality Assurance Section,

Recommendation D.a-13 RSRM Segment Shipping Security

NASA and ATK Thiokol perform a thorough security assessment of the RSRM segment security, from manufacturing to delivery to Kennedy Space Center, identifying vulnerabilities and identifying remedies for such vulnerabilities.

BACKGROUND

During security program assessments at the ATK Thiokol Reusable Solid Rocket Motor (RSRM) Production Facility, the *Columbia* Accident Investigation Board raised concerns about several elements of the overall security program. Most notable of these concerns was protection of completed segments prior to rail shipment to the Kennedy Space Center (KSC).

NASA IMPLEMENTATION

NASA will conduct a full security program vulnerability assessment of the ATK Thiokol RSRM Production Facility with the goal of identifying and mitigating security vulnerabilities.

In support of the return to flight activity, NASA security, in conjunction with ATK Thiokol Security Program officials, will perform an assessment of the RSRM security program from RSRM manufacturing to delivery, inspection, and

storage at KSC. The assessment will include a review of the ATK Thiokol manufacturing plant to the railhead, and the participation in the rail shipment activities of RSRM segment(s) to or from KSC, regional and local threats, and Rotation, Processing, and Storage Facility security at KSC.

STATUS

An assessment team has been formed and has developed assessment criteria and methodologies.

SCHEDULE

The date for completion of the security assessment has been set for March 2004 so that the assessment period will coincide with the next RSRM delivery from ATK Thiokol to KSC. A report will be developed identifying security vulnerabilities, if any, and remedies for those vulnerabilities.



Columbia Accident Investigation Board

Volume II, Appendix D.a, Quality Assurance Section,

Recommendation D.a-14 Michoud Assembly Facility Security

NASA and Lockheed-Martin complete an assessment of the Michoud Assembly Facility security, focusing on items to eliminate vulnerabilities in its current stance.

BACKGROUND

During security program assessments at the Michoud Assembly Facility (MAF), the *Columbia* Accident Investigation Board expressed concerns about several elements of the overall security program. Most notable of these concerns is the adequacy of particular security equipment and staffing.

NASA IMPLEMENTATION

NASA will conduct a full security program vulnerability assessment of the MAF and External Tank (ET) production activity with the goal of identifying and mitigating security vulnerabilities.

In support of return to flight, NASA Security, in conjunction with MAF Security Program officials, will assess the MAF and the ET production security programs from ET manufacturing to delivery, inspection, and storage at

Kennedy Space Center (KSC). The assessment will include a review of MAF to the shipping port, shipping activities of the ET to and from KSC, regional and local threats, and Vehicle Assembly Building security at KSC.

STATUS

An assessment team has been formed and has developed assessment criteria and methodologies.

SCHEDULE

The completion date of the security assessment has been set for March 2004 so that the assessment period will be adequate to perform a thorough assessment in accordance with NASA's Mission Essential Infrastructure Protection Program. A report identifying security vulnerabilities, if any, and remedies to mitigate identified vulnerabilities will follow.

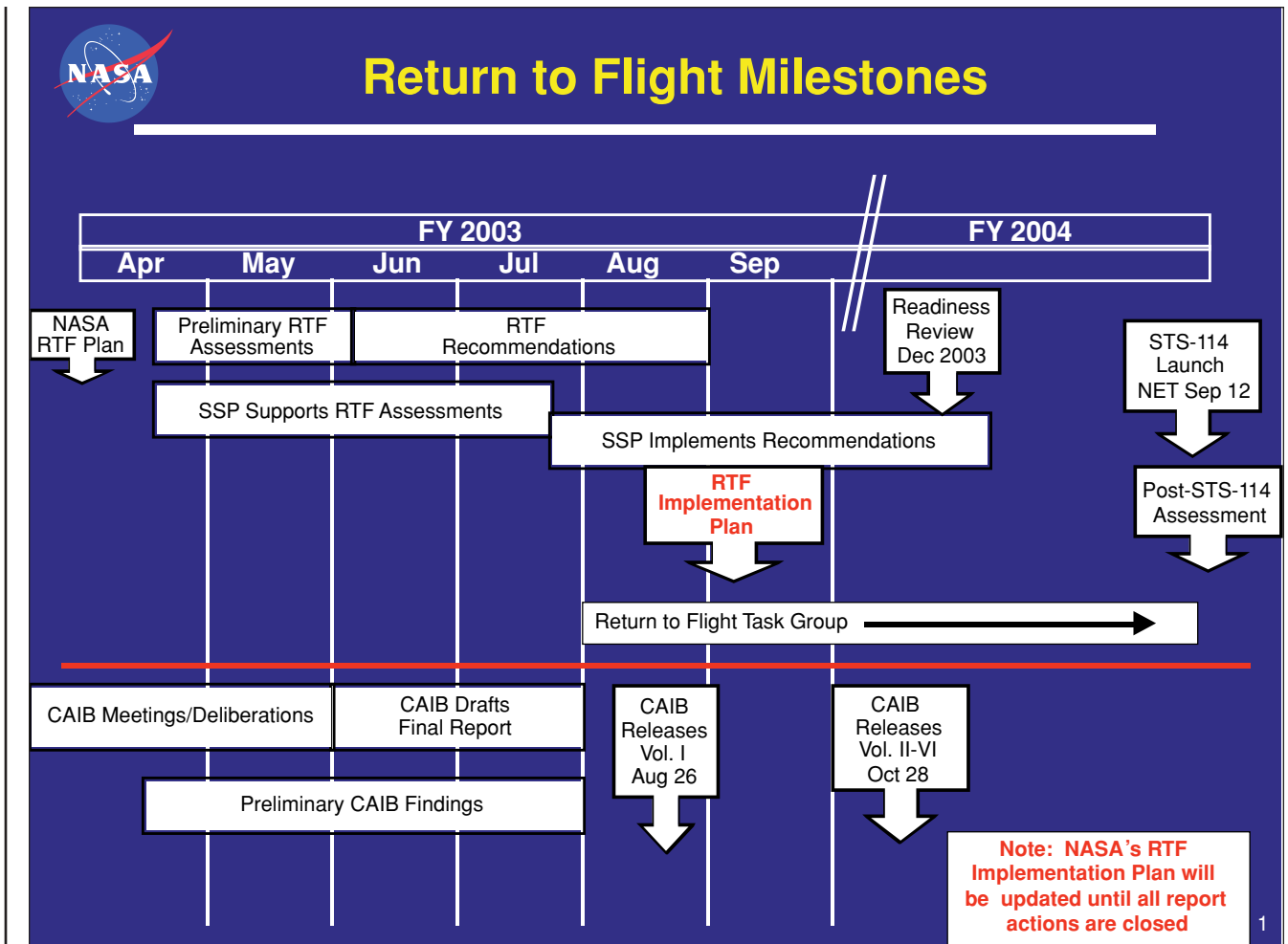
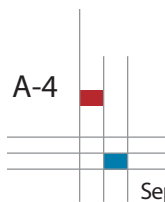


Figure A-4. RTF and RTFTG schedules overlaid with the schedule for release of the CAIB final report.



September 8, 2003

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MA SA's Implementation Plan for Space Shuttle Return to Flight and Beyond

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